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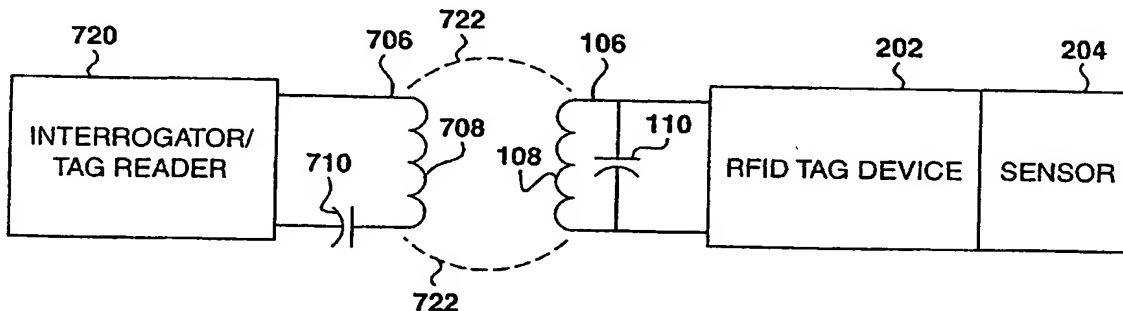
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(57) Abstract

A radio frequency identification tag device having a sensor input which modifies a tag data word bitstream read by an interrogator/tag detector. The sensor input may be a switch contact(s), digital and/or analog. The sensor input may be voltage, current, pressure, temperature, resistance, acceleration, moisture, gas and the like. Power from the radio frequency interrogator/tag reader may be used to power the circuits of the radio frequency tag device, which in turn may supply power to any sensor connected thereto.

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RADIO FREQUENCY IDENTIFICATION TAG DEVICE WITH SENSOR INPUT

Background of the Invention

This invention relates generally to radio frequency identification tag devices, and more particularly, to a radio frequency identification tag device with a sensor input which modifies a tag data word bitstream read by a tag interrogator/detector.

Description of the Related Technology

Radio frequency identification (RFID) tag devices may be used in managing inventory, automatic identification of cars on toll roads, security systems, electronic access cards and the like. RFID tag devices will work under more hostile environmental conditions than bar code labels since the RFID tag device may be read through paint, water, dirt, dust, human bodies, concrete, or through the tagged item itself. RFID tag devices are used in conjunction with a radio frequency tag reader (interrogator) which generates a continuous wave (CW) radio frequency (RF) carrier that activates the RFID tag device at close range. The RFID tag device is passive and has no internal power sources, rather it uses some of the power in the CW RF carrier to power internal circuits that read a stored internal digital code and cause the RFID tag device to signal its stored internal digital code to the tag reader.

The RFID tag device modifies the amplitude of the CW carrier of the interrogator by loading and unloading a resonant circuit which is tuned to the CW carrier. The RFID tag device comprises, for example, a parallel resonant circuit or antenna tuned to the frequency of the radio frequency CW carrier, an RF to direct current (DC) converter, a circuit for loading and unloading the parallel resonant circuit/antenna, logic which stores the internal digital code, logic which reads the internal digital code and causes the circuit for loading and unloading the parallel resonant circuit/antenna to operate in co-operation with the internally stored digital code.

The internal digital code of the RFID tag device, like information on a bar code, is normally fixed and cannot be changed except by command from the interrogator.

There are situations where an RFID tag device is associated with a piece of equipment such as a valve, a process monitor, etc., having variable status or information. This variable status or information may be, for example, from a binary on/off switch(es); an analog sensor detecting pressure, temperature, voltage, current, speed, moisture, pH, etc.; or a digital value from a counter or output of an analog to digital converter. Generally, means other than the RFID tag device is required to read this variable status or information. For example, contact or connection with the switch, sensor or digital value; visually reading a display value, or using an active RF system which continuously consumes power.

Therefore, what is needed is a more cost effective, simple and reliable system, method and apparatus for obtaining variable status or information from a tagged item.

SUMMARY OF THE INVENTION

The invention overcomes the above-identified problems as well as other shortcomings and deficiencies of existing technologies by providing in an RFID tag device a sensor input adapted to receive variable signals from a switch(es), an analog variable or a digital variable. Typically, the RFID tag device amplitude modulates the CW RF carrier of the RF generator with its data word bitstream by loading and unloading the resonant tuned circuit or antenna of the RFID tag device in accordance with the binary values of that data word bitstream. The data word bitstream is a series of on/off pulses which represent, for example, a serial data word synchronization header, the RFID tag number, and, according to the embodiments of the invention, a sensor value(s). Parity bits or a checksum value may also be incorporated into the data word bitstream. These series of on/off pulses are detected by the tag reader/interrogator which determines amplitude variations of its CW RF signal. These amplitude variations are caused by the electro-magnetically coupled or RF antenna coupled RFID tag device loading and unloading the tuned circuit or antenna, respectively, of the tag reader/interrogator.

In accordance with an embodiment of the present invention, an RFID tag device has a digital input (on/off) for sensing a discrete change in voltage, current or resistance

of a sensor connected to the digital input. The digital input sense state may determine whether a bit is set or cleared in the data word bitstream or whether the data word bitstream bit values may be inverted. Either way, the difference between the two data word bitstreams represent the change in the sensor (open or closed) which represents whatever the sensor represents, i.e., open or closed valve, circuit breaker on or tripped, and the like. A source of voltage or current for the sensor may be obtained from an external source, or from the RFID tag device itself which then supplies some of the power from the electro-magnetically coupled or RF antenna coupled CW from the interrogator/tag reader. The sensor may be an electro-mechanical switch, a transistor, a hall effect device, a photo-transistor and the like.

Another embodiment of the RFID tag device has a plurality of digital inputs (on/off) for sensing discrete changes in voltage, current or resistance of sensors or circuits connected to the plurality of digital inputs. The sense states of the digital inputs determine which ones of a plurality of bits are set or cleared in the data word bitstream. A source of voltage or current for the sensors or circuits connected to the digital inputs may be obtained from an external source or from the RFID tag device itself which uses some of the power from the electro-magnetically coupled or RF antenna CW from the interrogator/tag reader. The sensors or circuits connected to the digital inputs may be electro-mechanical switches, transistors, hall effect devices, photo-transistors, the output of an analog-to-digital converter, and the like.

Still another embodiment of the RFID tag device has an analog input for sensing an analog sensor signal represented by a variable voltage, current or resistance value. The analog input may be converted to a digital value by an analog-to-digital converter which is also part of the circuits of the RFID tag device. The analog input may also be converted to an on/off, high/low representation by a voltage comparator. A plurality of analog inputs may be used with the present invention, each analog input having a digital value. The plurality of analog inputs may be processed through an analog multiplexer into the analog-to-digital converter, and/or a voltage comparator. Voltage or current for powering the analog sensor(s) may be obtained from an external

source, or from the RFID tag device which uses some of the power from the electro-magnetically coupled or RF antenna coupled CW from the interrogator/tag reader. The analog sensor(s) may be an RTD, thermocouple, piezo-electric pressure transducer and the like.

5 Yet another embodiment of the RFID tag device has a sensor built into the tag device itself. The sensed value may be for example: pressure, temperature, acceleration, vibration, moisture content, gas percentage, density, flow rate, light intensity, sound intensity, radiation, magnetic flux, pH, etc. The converted digital value read from the sensor input is transmitted as part of the data word bitstream. The analog
10 output of the sensor may be converted to a digital value by an analog-to-digital converter within the RFID tag device. The analog sensor output may also be converted to an on/off, high/low representation by a voltage comparator. A plurality of analog sensor outputs may be converted within the RFID tag device into digital values. The plurality of analog sensor outputs may be processed through an analog multiplexer into
15 an analog-to-digital converter, and/or a voltage comparator. Voltage or current for powering the analog sensor(s) may be obtained from an external source, or from the RFID tag device which then supplies some of the power from the electro-magnetically coupled or RF antenna coupled CW from the interrogator/tag reader.

Any of the aforementioned embodiments may incorporate dual-purpose external
20 connection pads in which the pad has one function before setting a lock function in the RFID tag device, and a separate function after locking the device or writing to a particular register. For example, a dual-function pad may be used as a reset function before locking a memory array, and as a digital input after locking the memory array.

The RFID tag device may be fabricated onto a single semiconductor integrated
25 circuit die, or it may be comprised of a plurality of semiconductor dice in a single integrated circuit package. It is also contemplated and within the scope of the invention that multi-device RFID tags incorporating a plurality of discrete electronic devices, including but not limited to, microcontrollers, memories, digital logic circuits, analog

circuits, and discrete and/or monolithic transducer/sensors, may be fabricated into any of the aforementioned embodiments.

Features and advantages of the invention will be apparent from the following description of presently preferred embodiments, given for the purpose of disclosure and
5 taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1A and 1B are schematic block diagrams of embodiments of the invention adapted for connection to an external sensor;

10 Figures 2A and 2B are schematic block diagrams of embodiments of the invention having an integral sensor;

Figures 3A and 3B are schematic block diagrams of embodiments of the invention adapted for connection to an analog sensor;

Figures 4A and 4B are schematic block diagrams of embodiments of the invention adapted for connection to a plurality of analog sensors;

15 Figures 5A and 5B are schematic block diagrams of embodiments of the invention adapted for connection to a plurality of external sensors;

Figures 6A and 6B are schematic block diagrams of embodiments of the invention supplying power for operation of a sensor;

20 Figures 7A and 7B are schematic block diagrams representative of the inductive and RF embodiments of the invention and inductive and RF interrogator/tag readers, respectively;

Figures 8a and 8b are schematic tables of data word bitstreams for different sensor states according to the invention; and

Figures 9a-9c are schematic tables of data word bitstreams based upon changing sensor inputs.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The invention is a radio frequency identification (RFID) tag device having a
5 sensor input which causes logic circuits within the RFID tag device to modify an
identification data word bitstream of the RFID tag device. The RFID tag device is
passive, having no internal power storage, and relies upon power for its circuits from
near-field or far-field continuous wave (CW) radio frequency (RF). Whenever the
RFID tag device is in proximity to the CW RF field, the RFID tag device draws power
10 from the field through electro-magnetic or RF coupling. The amplitude of the CW RF
carrier is affected by the RFID tag device being in proximity therewith. The CW RF
generator has an interrogator which detects changes in the amplitude of the CW RF
carrier and has a logic circuit which looks for a pattern(s) in these amplitude changes
over a period of time. When a recognizable pattern is detected, an RFID tag device has
15 been detected and information within the recognized pattern may be utilized.

Referring now to the drawings, the details of preferred embodiments of the
invention are schematically illustrated. Like elements in the drawings will be represented
by like numbers, and similar elements will be represented by like numbers with a different
lower case letter suffix.

20 Referring now to Figures 1A and 1B, schematic block diagrams of
embodiments of the invention, adapted for connection to external sensors, are
illustrated. An RFID tag device 102 comprises a parallel tuned circuit 106 made up of
an inductor 108 and a capacitor 110 (Figure 1A), or a RF ultra high frequency (UHF) or
microwave antenna 116 (Figure 1B). The RFID tag device 102 has an input 112
25 adapted to receive a signal from a sensor 104. The sensor 104 may have two states, on
or off, such as a switch, a transistor, a hall effect device, a photo-transistor and the like.
The sensor 104 may also be analog, i.e., having a plurality of values that vary with
time. The signal from the sensor 104 may be a voltage, current, resistance, frequency
and the like. The RFID tag device 102 may also provide power to the sensor 104.

Power to the sensor is represented by power connection 114. The RFID tag device 102 generates a data word bitstream that is read by an interrogator/tag reader 720 (see Figure 7). Within this data word bitstream is information relating to a signal value from the sensor 104. When the signal value of the sensor 104 changes, so does the information of the data word bitstream. It is contemplated and within the scope of the present invention to have the sensor 104 in the same package as the RFID tag device 102. This results in a compact and cost effective packaged device that requires no internal power storage (batteries) and may be fabricated into a variety of shapes and applications.

Referring now to Figures 2A and 2B, schematic block diagrams of embodiments of the invention having integral sensors are illustrated. An RFID tag device 202 and a sensor 204 are integral on an semiconductor integrated circuit die, or both are contained in an integrated circuit package (not illustrated). The sensor 204 may be binary digital (on/off), or it may be analog. The sensor 204 may be adapted to measure voltage, current, resistance, frequency, pressure, temperature, acceleration, vibration, moisture content, gas percentage, density, flow rate, light intensity, sound intensity, radiation, magnetic flux, pH, etc. The RFID tag device 202 generates a data word bitstream that is read by the interrogator/tag reader 720 (see Figure 7). Within this data word bitstream is information relating to a value from the sensor 204. When the signal value of the sensor 204 changes, so does the information in the data word bitstream.

Referring now to Figures 3A and 3B, schematic block diagrams of embodiments of the invention adapted for connection to analog sensors are illustrated. An RFID tag device 302 comprises a parallel tuned RF circuit 106 made up of an inductor 108 and a capacitor 110 (Figure 3A), or a RF ultra high frequency (UHF) or microwave antenna 116 (Figure 3B). A memory array 314 stores a digital output from an analog-to-digital converter (ADC) 312. The ADC 312 is adapted to receive an analog output from an analog sensor 304. The analog sensor 304 may be external to, or part of, a package containing the RFID tag device 302, the memory array 314, and the

ADC 312. The ADC 312 converts the analog output signal from the sensor 304 to a digital value of this signal. The memory array 314 stores the digital value and logic within the RFID tag device 302 and combines the stored digital value with other digital information in the data word bitstream. The data word bitstream may comprise, but not
5 be limited to, a synchronization header, identification code, sensor value, and parity bits or a checksum. The data word bitstream is detected by a tag reader 720 (Figure 7) and the value of the sensor 304 may be displayed from the information supplied by the tag reader 720.

Referring to Figures 4A and 4B, schematic block diagrams of embodiment of
10 the invention, adapted for connection to a plurality of analog sensors, are illustrated. The RFID tag device 302 comprises a parallel tuned RF circuit 106 made up of an inductor 108 and a capacitor 110 (Figure 4A), or a RF ultra high frequency (UHF) or microwave antenna 116 (Figure 4B). The memory array 314 stores digital outputs from an analog-to-digital converter (ADC) 312. The ADC 312 receives an analog output
15 from an analog multiplexer 416. The analog multiplexer 416 selects the outputs from a plurality of analog sensors 404a-404d. The memory array 314 stores a digital value from the ADC 312 for each of the plurality of analog sensors 404a-404d. The digital values stored in the memory array 314 are combined with other digital information in the data word bitstream. The data word bitstream may comprise, but not be limited to,
20 a synchronization header, identification code, sensor values, and parity bits or a checksum. The data word bitstream is detected by an interrogator/tag reader 720 (Figure 7) and the values of the sensors 404a-404d may be displayed from the information supplied by the interrogator/tag reader 720. The RFID tag device 302, memory array 314, ADC 312 and multiplexer 416 may be fabricated on the same
25 semiconductor integrated circuit die, in combination on different integrated circuit dice packaged together in a single package, or separately in two or more integrated circuit packages connected together on a substrate such as a printed circuit board or printed wiring board (not illustrated).

Referring now to Figures 5A and 5B, schematic block diagrams of embodiments of the invention, adapted for connection to a plurality of external sensors, are illustrated. An RFID tag device 102 comprises a parallel tuned RF circuit 106 made up of an inductor 108 and a capacitor 110 (Figure 5A), or a RF ultra high frequency (UHF) or microwave antenna 116 (Figure 5B).. The RFID tag device 102 has a plurality of inputs 512a-512d adapted to receive signals from the plurality of sensors 504a-504d. The plurality of sensors 504a-504d may have two states, on or off, such as a switch, a transistor, a hall effect device, a photo-transistor and the like. The RFID tag device 102 may also provide power to the plurality of sensors 504a-504d, as described below. The RFID tag device 102 generates a data word bitstream that is read by an interrogator/tag reader 720 (see Figure 7). Within this data word bitstream is information relating to signal values from the sensors 504a-504d. When the signal values of the sensors 504a-504d change, so does the respective information of the data word bitstream.

Referring to Figures 6A and 6B, schematic block diagrams of embodiments of the invention supplying power for operation of sensor(s) are illustrated. A sensor interface 618 has an input 612 adapted to receive a signal from the sensor 604, and to also supply power 620 to the sensor 604 for operation thereof. The sensor 604 may be digital or analog and operate as described above. The input 612 may be used for a dual purpose of a first function input before setting, for example, a lock function in the RFID tag device 302 and/or memory array 614 and a second function input after locking or writing to a particular register of the memory array 614, i.e., the first function input may be a reset and the second function input may be adapted for a sensor input. The input resistance of the dual purpose input 612 may also change, i.e., in the first function input a low resistance and in the second function input a high resistance, or visa-versa.

Referring to Figures 7A and 7B, schematic block diagrams representative of the embodiments of the invention and a radio frequency generator/interrogator/tag reader. The tuned circuit 706 comprises inductor 708 and capacitor 710 connected in series.

RF generator/interrogator/tag reader 720 produces CW RF power across the tuned circuit 706 (Figure 7A) or antenna 716 (Figure 7B). This CW RF power is electro-magnetically coupled by alternating current action to the parallel tuned circuit 106 or antenna 116. The CW RF electro-magnetic power is generally represented by the numeral 722 (Figure 7A) and the UHF/microwave power is generally represented by the numeral 718 (Figure 7B). The RFID tag device 202 has circuits which convert some of the CW RF electro-magnetic power 722 or UHF/microwave power 718 into direct current power for use by the logic circuits of the RFID tag device 202 and for powering the circuits of the sensor 204.

Whenever the tuned circuit 106 of the RFID tag device 202 is in proximity to the tuned circuit 706 of the RF generator/interrogator/tag reader 720, a voltage amplitude across the tuned circuit 706 is reduced because the RFID tag device 202 loads the tuned circuit 706. If the tuned circuit 106 of the RFID tag device 202 is taken out of resonance by circuits therein, then the RFID tag device 202 does not load the turned circuit 706 and the voltage amplitude across the tuned circuit 706 increases back to what it was before the RFID tag device 202 came in proximity thereto. The RFID tag device 202 causes amplitude changes in the tuned circuit 706 so as to convey information in a serial data word bitstream of on/off pulses. The interrogator/tag reader 720 detects these CW RF amplitude changes and converts them into a detected serial data word bitstream of on/off pulses representative of the information from the RFID tag device 202. The antenna 716 works in a similar fashion.

Referring to Figures 8a and 8b, schematic tables of data word bitstreams for different sensor states, according to the invention, are illustrated. A data word represented by the tables of numbers of Figures 8a and 8b may be transmitted as a serial bitstream as described hereinabove. Row 802 is a hexadecimal representation and row 804 is a binary representation of the data word. A data header may be comprised of four-bit groups 806, 808 and 810. A data/tag serial number may be comprised of the remaining four-bit groups 812-840. The data header and data/tag serial number data word may be a non-inverted data stream for a first state of the sensor

and an inverted data stream for a second state of the sensor. The first state is represented by groups 806-840 and the second state is represented by groups 806a-840a. This may effectively be used to convey, for example, a switch position to the interrogator/tag reader 720. The interrogator/tag reader 720 (Figure 7) searches
5 detected bits to find a correct header and/or checksum in order to find and validate the data word. If the tag reader 720 cannot find the data word pattern it can search for the inverse of the anticipated bitstream, and, if found, the sensor is in the second state.

Referring to Figures 9a-9c, schematic tables of data word bitstreams based upon changing sensor inputs are illustrated. A data word represented by the tables of numbers
10 of Figures 9a, 9b and 9c may be transmitted as a serial bitstream as described hereinabove. A data header may be comprised of the four-bit groups 806, 808 and 810. A data/tag serial number may be comprised of the four-bit groups 812-836. A digital value representing the analog sensor input value may be comprised of four-bit groups 950 and 952. A checksum or parity bits may be comprised of x bits 954. The x bits
15 954 may be used for verification or correction of the data word or the entire bitstream. In Figure 9a, the four-bit groups 950a and 952a represent a sensor value of zero scale. In Figure 9b, the four-bit groups 950b and 952b represent a sensor value of half scale. In Figure 9c, the four-bit groups 950c and 952c represent a sensor value of full scale.

The above embodiments of the invention may be used to keep track of the status
20 and/or condition of an article of manufacture or apparatus. For example but not limitation: 1) rental car identification, amount of gas in the rental car tank, mileage, etc.; 2) pressure, temperature and/or weight of a truck, ship or railroad car; 3) tire serial number and air pressure, and 4) animal body temperature, blood chemistry, heart rate, etc.

25 The invention, therefore, is well adapted to carry out the objects and attain the ends and advantages mentioned, as well as others inherent therein. While the invention has been depicted, described, and is defined by reference to particular preferred embodiments of the invention, such references do not imply a limitation on the invention, and no such limitation is to be inferred. The invention is capable of

considerable modification, alternation, and equivalents in form and function, as will occur to those ordinarily skilled in the pertinent arts. The depicted and described preferred embodiments of the invention are exemplary only, and are not exhaustive of the scope of the invention. Consequently, the invention is intended to be limited only
5 by the spirit and scope of the appended claims, giving full cognizance to equivalents in all respects.

CLAIMS

What is claimed is:

1. A radio frequency identification tag device having a sensor input, comprising:
 - 5 a radio frequency tuned circuit;
 - a logic circuit having a data register;
 - a radio frequency switch circuit for loading and unloading said radio frequency tuned circuit;
 - a sensor input circuit; and
 - 10 a power converter circuit for converting radio frequency power into direct current power for powering said circuits of said radio frequency identification tag device; wherein,
 - said sensor input circuit being used to modify the data register contents, and said logic circuit using the data register contents to control said radio frequency switch
 - 15 circuit.
2. The radio frequency identification tag device of claim 1, further comprising a header value which also controls said radio frequency switch circuit.
3. The radio frequency identification tag device of claim 1, further comprising an identification value which also controls said radio frequency switch circuit.
- 20 4. The radio frequency identification tag device of claim 1, further comprising a parity value which also controls said radio frequency switch circuit.
5. The radio frequency identification tag device of claim 1, further comprising a checksum value which also controls said radio frequency switch circuit.
- 25 6. The radio frequency identification tag device of claim 1, wherein the data register contents are modified by inverting the bit pattern therein.

7. The radio frequency identification tag device of claim 1, wherein said radio frequency switch circuit is controlled by a serial data word bitstream.

8. The radio frequency identification tag device of claim 1, wherein said sensor input circuit is an analog input circuit.

5 9. The radio frequency identification tag device of claim 8, wherein said sensor input circuit is an analog to digital converter.

10. The radio frequency identification tag device of claim 8, wherein said sensor input circuit is a voltage comparator.

10 11. The radio frequency identification tag device of claim 1, wherein said sensor input circuit is a digital input circuit having a first input level and a second input level.

12. The radio frequency identification tag device of claim 11, wherein the data register contains a binary bit pattern when said digital input circuit is at the first input level, and an inverted binary bit pattern when said digital input circuit is at the second input level.
15

13. The radio frequency identification tag device of claim 11, wherein said digital input circuit is adapted to sense the first and second input levels as first and second voltages, respectively.

14. The radio frequency identification tag device of claim 11, wherein said digital input circuit is adapted to sense the first and second input levels as first and second currents, respectively.
20

15. The radio frequency identification tag device of claim 11, wherein said digital input circuit is adapted to sense the first and second input levels as first and second resistances, respectively.

16. The radio frequency identification tag device of claim 1, wherein said sensor input circuit is a plurality of sensor input circuits.

17. The radio frequency identification tag device of claim 16, wherein said plurality of sensor input circuits are a plurality of inputs of an analog input multiplexer.

5 18. The radio frequency identification tag device of claim 17, further comprising an analog to digital converter having an analog input connected to said analog input multiplexer output and a digital output value stored in the data register.

19. The radio frequency identification tag device of claim 1, further comprising a power output from said power converter circuit for powering a sensor.

10 20. The radio frequency identification tag device of claim 1, further comprising an un-packaged integrated circuit die.

21. The radio frequency identification tag device of claim 1, further comprising an integrated circuit package.

15 22. The radio frequency identification tag device of claim 1, further comprising at least one integrated circuit package on a printed wiring board.

23. A radio frequency identification tag device, comprising:
a radio frequency tuned circuit;
a logic circuit having a data register;
a radio frequency switch circuit for loading and unloading said radio frequency
20 tuned circuit;
a sensor having an output which is used to modify the data register contents;
and
a power converter circuit for converting radio frequency power into direct
current power for powering said circuits of said radio frequency identification tag
25 device; wherein,

said logic circuit uses the data register contents to control said radio frequency switch circuit.

24. The radio frequency identification tag device of claim 23, wherein said sensor output is used to modify a portion of the data register contents, another portion
5 of the data register contents is unmodified.

25. The radio frequency identification tag device of claim 24, wherein the another portion of the data register contents comprises a header and an identification value.

26. The radio frequency identification tag device of claim 25, wherein the
10 another portion of the data register contents further comprises a parity value.

27. The radio frequency identification tag device of claim 25, wherein the another portion of the data register contents further comprises a checksum value for correcting bit errors of the data register contents when sent as a data word bitstream.

28. The radio frequency identification tag device of claim 23, wherein said
15 sensor is a plurality of sensors.

29. The radio frequency identification tag device of claim 23, wherein said sensor is a digital sensor adapted for determining first and second conditions of an input to said digital sensor.

30. The radio frequency identification tag device of claim 29, wherein the
20 input to said digital sensor is selected from the group consisting of voltage, current, resistance, frequency, pressure, temperature, acceleration, vibration, moisture content, gas percentage, density, flow rate, light intensity, sound intensity, radiation, magnetic flux and pH.

31. The radio frequency identification tag device of claim 23, wherein said
25 sensor is an analog sensor adapted for determining a plurality of conditions of an input to said analog sensor.

32. The radio frequency identification tag device of claim 31, wherein the input to said analog sensor is selected from the group consisting of voltage, current, resistance, frequency, pressure, temperature, acceleration, vibration, moisture content, gas percentage, density, flow rate, light intensity, sound intensity, radiation, magnetic
5 flux and pH.

33. A method for determining a process value and an identification thereof, said method comprising the steps of:

- measuring a process value with a sensor;
- storing the measured process value in a data register;
- 10 storing a sensor identification value in the data register;
- generating a data word bitstream from the measured process value and sensor identification value stored in the data register; and
- loading and unloading of a radio frequency circuit with the serial data word bitstream, wherein the loading and unloading changes depend on the bit pattern of the
15 data word bitstream.

34. The method of claim 33, wherein the step of generating a data word bitstream includes the step of generating a frame header for the measured process value and sensor identification value.

35. The method of claim 33, wherein the step of generating a data word
20 bitstream includes the step of generating parity bits for the measured process value and sensor identification value.

36. The method of claim 33, wherein the step of generating a data word bitstream includes the step of generating a checksum value for correcting a transmission error in the measured process value and sensor identification value.

37. The method of claim 33, wherein the step of measuring a process value
25 with a sensor comprises the step of measuring a plurality of process values with a plurality of sensors.

38. The method of claim 33, wherein the process value is selected from the group consisting of voltage, current, resistance, frequency, pressure, temperature, acceleration, vibration, moisture content, gas percentage, density, flow rate, light intensity, sound intensity, radiation, magnetic flux and pH.

5 39. The method of claim 33, wherein the step of storing the measured process value, further includes the steps of converting an analog process value to a digital value with an analog to digital converter and storing the digital value in the data register for generating the data word bitstream.

40. The method of claim 33, further comprises the steps of:
10 reading a plurality of process values; and
storing the plurality of process values in the data register;

41. A system for identifying and reading a sensor value, said system comprising:

a radio frequency identification tag device having a sensor input, a radio
15 frequency tuned circuit, a logic circuit having a data register, a radio frequency switch circuit for loading and unloading said radio frequency tuned circuit, and a power converter circuit for converting radio frequency power into direct current power for powering said circuits of said radio frequency identification tag device; wherein, said sensor input circuit being used to modify the data register contents, and said logic
20 circuit using the data register contents to control said radio frequency switch circuit;

a sensor for measuring a process value, said sensor connected to said sensor input;

a radio frequency interrogator for generating radio frequency power at a frequency compatible with said tuned circuit; and

25 an identification tag reader connected to said radio frequency interrogator; said identification tag reader detecting amplitude variations of the radio frequency power for determining the data register contents of said radio frequency tag device.

42. The system of claim 41, wherein the process value is selected from the group consisting of speed of a vehicle, amount of gasoline in the vehicle tank, mileage of the vehicle and identification of the vehicle.

43. The system of claim 41, wherein the process value is selected from the
5 group consisting of pressure, temperature and weight.

44. The system of claim 41, wherein the process value is selected from the group consisting of body temperature, blood chemistry and heart rate.

45. The system of claim 41, wherein said sensor is a plurality of sensors, said
10 sensor input is a plurality of sensor inputs and the process value is a plurality of process values.

46. The system of claim 42, wherein the plurality of process values are amount of gasoline in a vehicle gas tank, mileage of the vehicle and identification of the vehicle.

47. The system of claim 41, wherein the process value is selected from the
15 group consisting of voltage, current, resistance, frequency, pressure, temperature, acceleration, vibration, moisture content, gas percentage, density, flow rate, light intensity, sound intensity, radiation, magnetic flux and pH.

48. The radio frequency identification tag device of claim 1, wherein said radio frequency tuned circuit comprises an inductor and capacitor.

49. The radio frequency identification tag device of claim 1, wherein said
20 radio frequency tuned circuit comprises a radio frequency antenna.

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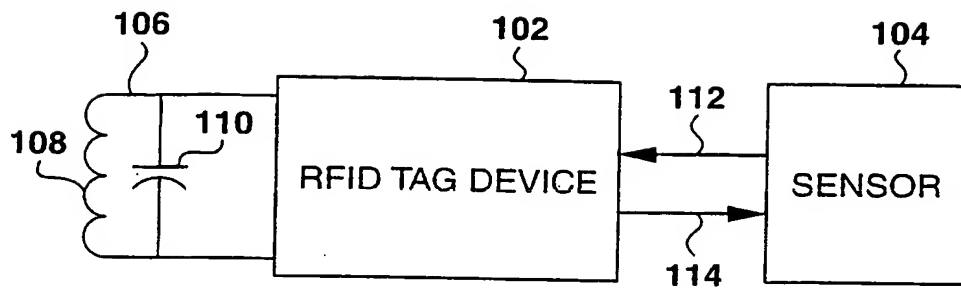


Fig. 1a

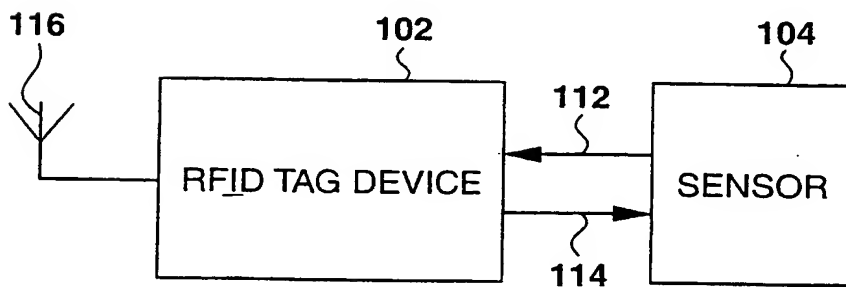


Fig. 1b

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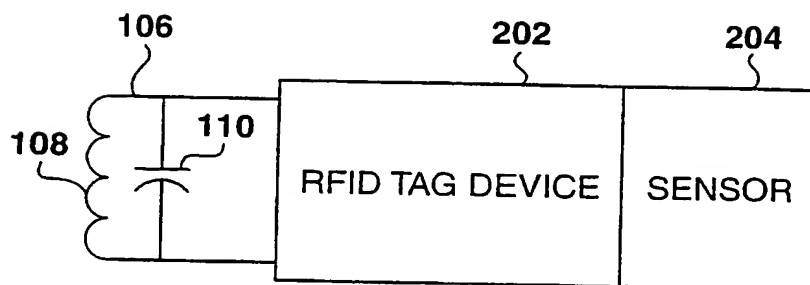


Fig. 2a

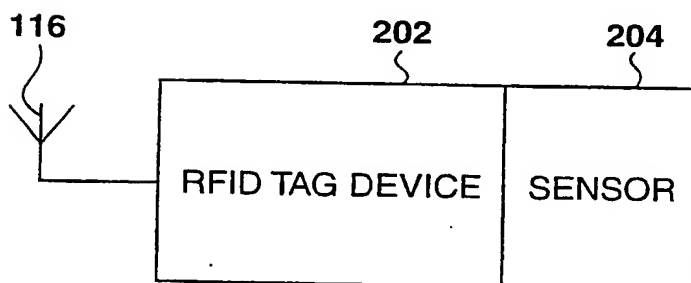


Fig. 2b

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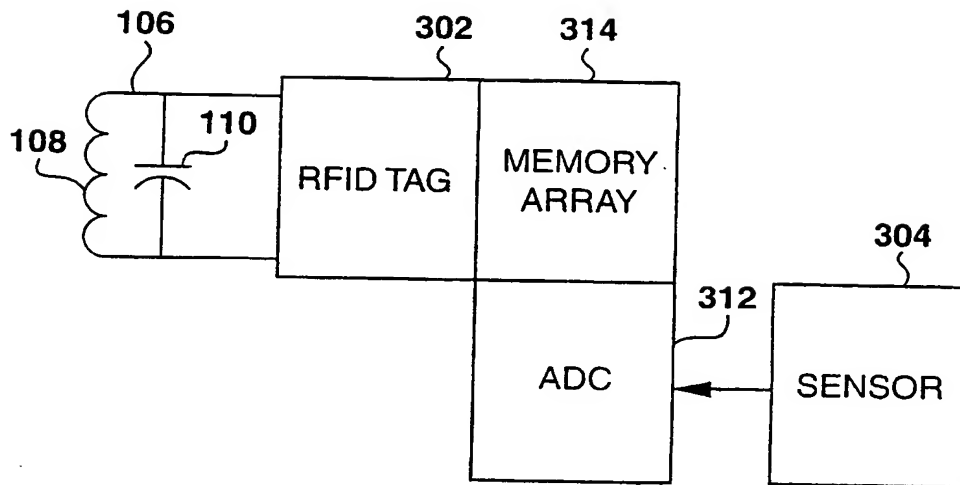


Fig. 3a

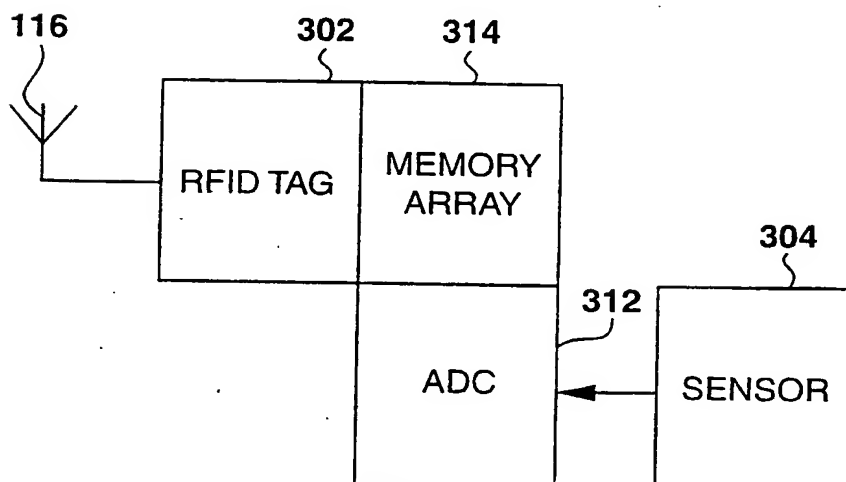


Fig. 3b

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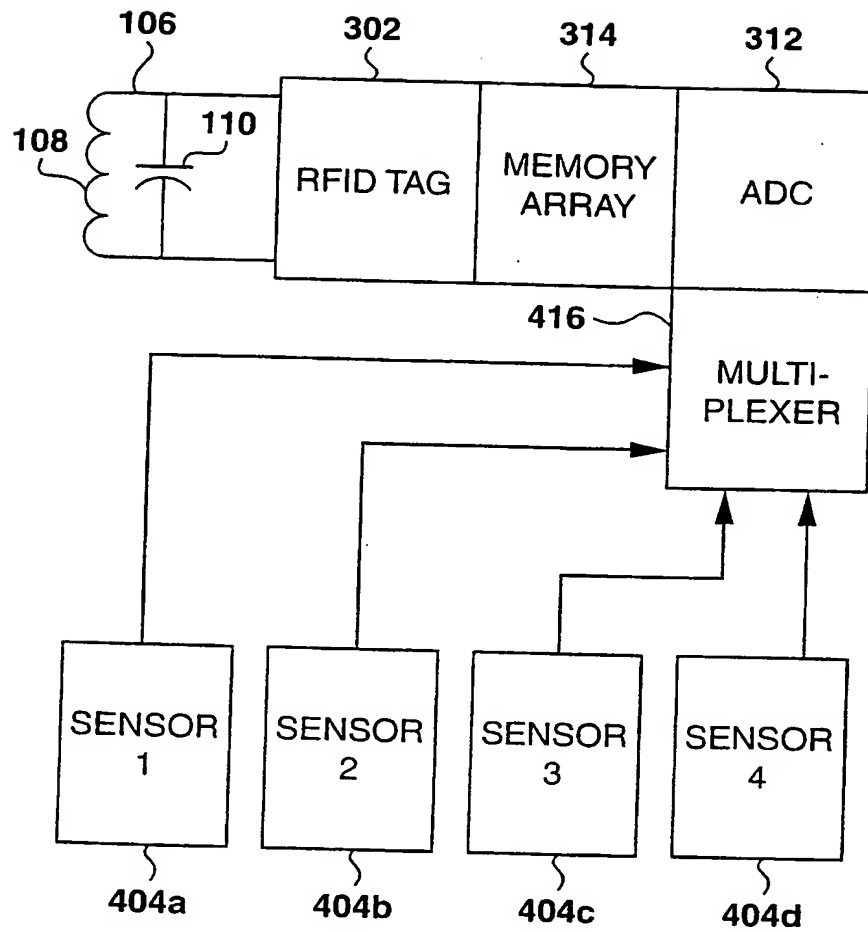


Fig. 4a

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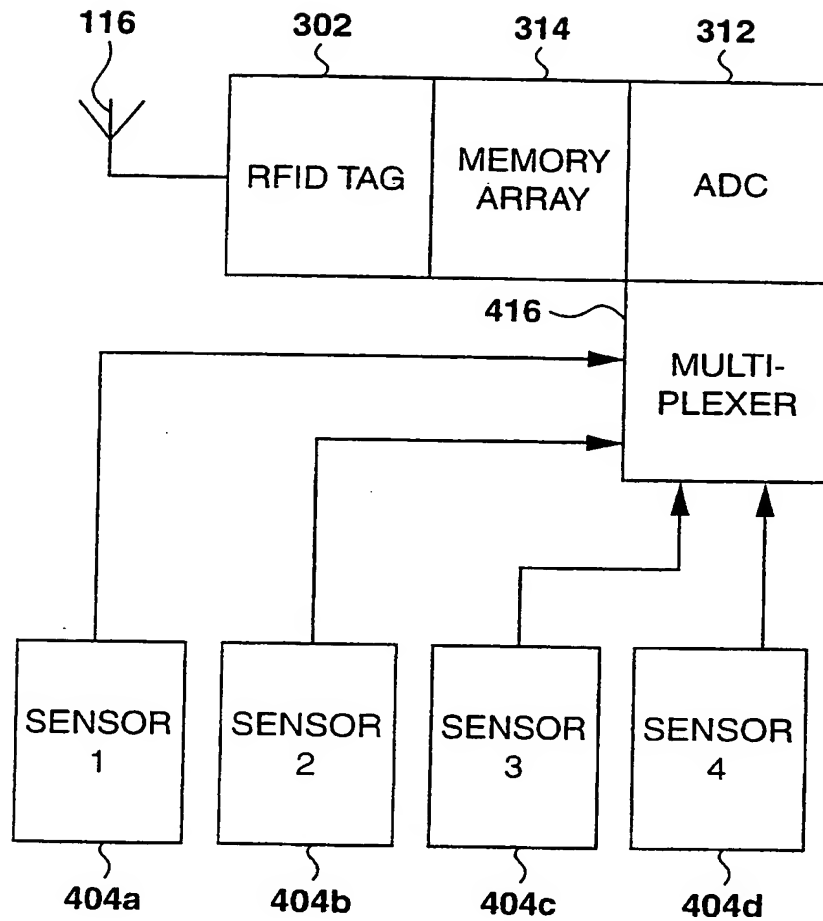


Fig. 4b

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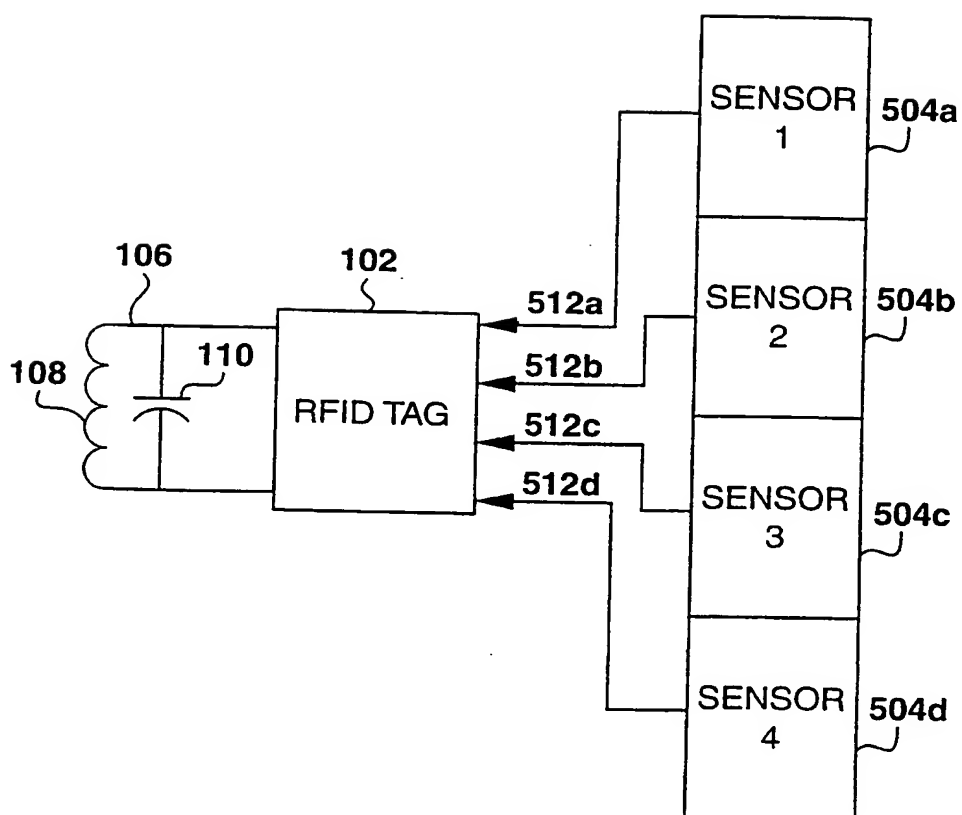


Fig. 5a

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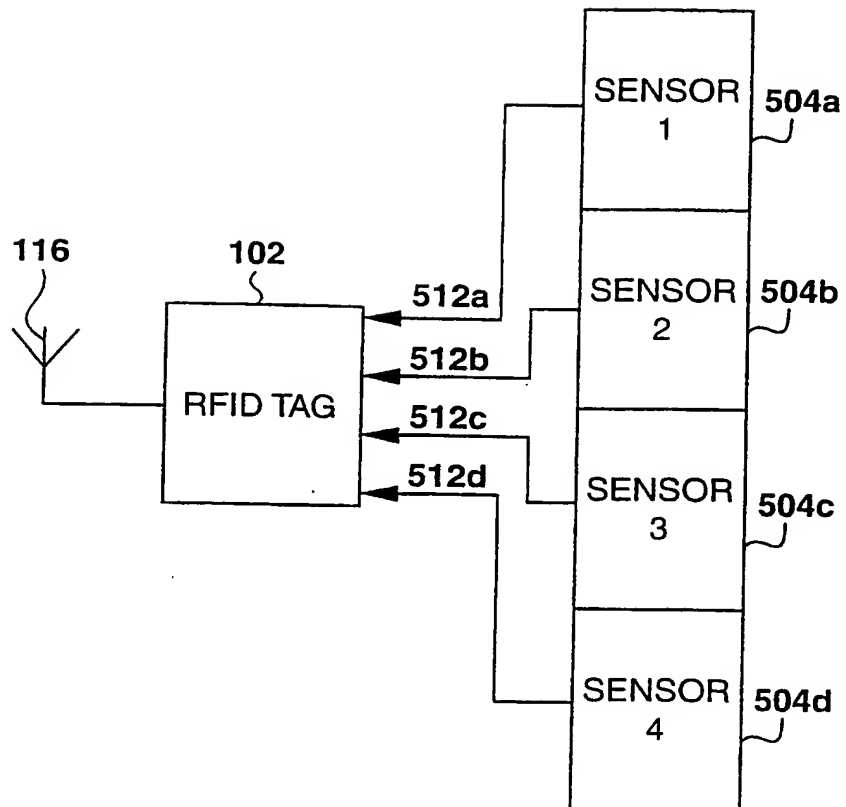


Fig. 5b

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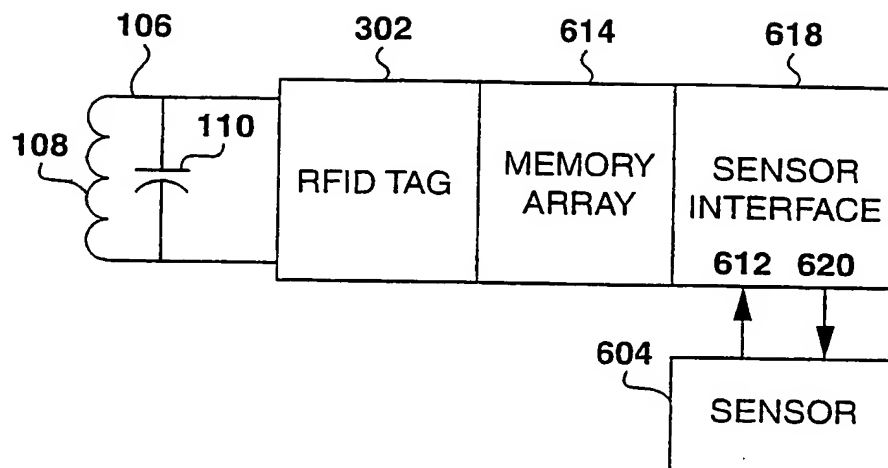


Fig. 6a

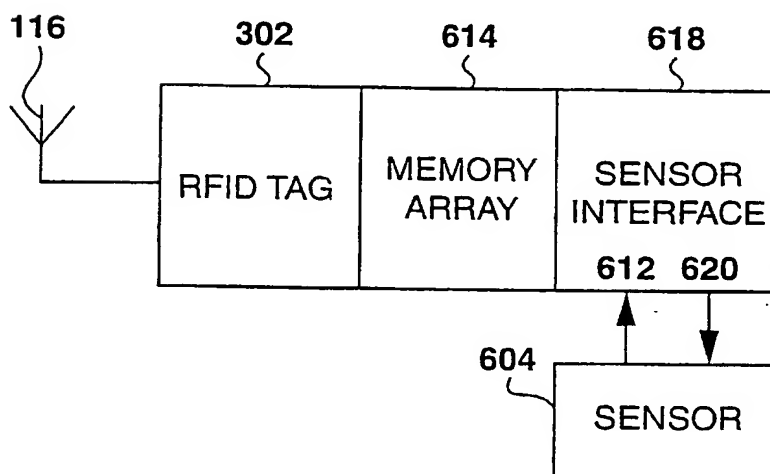


Fig. 6b

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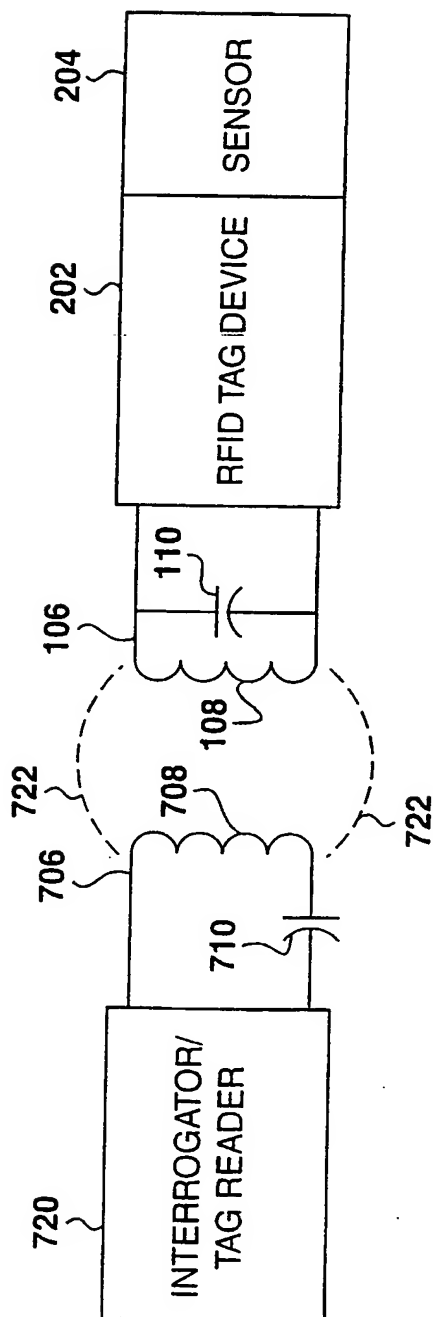


Fig. 7a

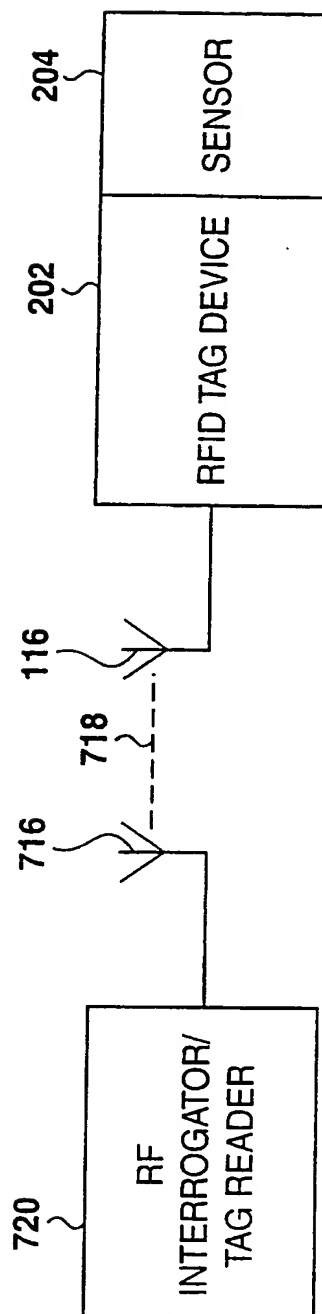


Fig. 7b

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802	8	2	A	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
804	1000	0010	1010	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
	806	808	810	812	814	816	818	820	822	824	826	828	830	832	834	836	838	840

Fig. 8a

802	8	2	A	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
804	0111	1101	0101	1110	1101	1100	1011	1010	1001	1000	0111	0110	0101	0100	0011	0010	0001	0000
	806a	808a	810a	812a	814a	816a	818a	820a	822a	824a	826a	828a	830a	832a	834a	836a	838a	840a

Fig. 8b

8	2	A	1	2	3	4	5	6	7	8	9	A	B	C	D	-	-
1000	0010	1010	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	0000	X
806	808	810	812	814	816	818	820	822	824	826	828	830	832	834	836	950a	954a

Fig. 9a

8	2	A	1	2	3	4	5	6	7	8	9	A	B	C	D	-	-
1000	0010	1010	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	0111	X
806	808	810	812	814	816	818	820	822	824	826	828	830	832	834	836	950b	954b

Fig. 9b

8	2	A	1	2	3	4	5	6	7	8	9	A	B	C	D	-	-
1000	0010	1010	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1111	X
806	808	810	812	814	816	818	820	822	824	826	828	830	832	834	836	950c	954c

Fig. 9c

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INTERNATIONAL SEARCH REPORT

Int .tional Application No
PCT/US 00/08125

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01S13/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 744 627 A (PALOMAR TECHN CORP) 27 November 1996 (1996-11-27) column 1, line 30 -column 1, line 45 column 3, line 49 -column 6, line 45	1-49
X	US 5 252 962 A (ELLWOOD DAVID ET AL) 12 October 1993 (1993-10-12) column 3, line 21 -column 11, line 9	1-49
X	US 4 068 232 A (MEYERS THOMAS D ET AL) 10 January 1978 (1978-01-10) column 2, line 58 -column 8, line 63	1-49
X	EP 0 440 153 A (TEXAS INSTRUMENTS DEUTSCHLAND) 7 August 1991 (1991-08-07) column 1, line 34 -column 5, line 37	1-49

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19 June 2000

Date of mailing of the international search report

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Information on patent family members

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PCT/US 00/08125

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0744627	A	27-11-1996	CA 2176790 A	26-11-1996
US 5252962	A	12-10-1993	AU 666062 B	25-01-1996
			AU 5501294 A	21-04-1994
			AU 660868 B	06-07-1995
			AU 5501394 A	28-04-1994
			AU 650891 B	07-07-1994
			AU 8154691 A	06-02-1992
			CA 2048385 A,C	04-02-1992
			CA 2189461 A	04-02-1992
			CA 2189462 A	04-02-1992
			CH 682782 A	15-11-1993
			DE 4125746 A	06-02-1992
			DE 4143560 C	15-01-1998
			DE 4143561 C	29-01-1998
			FR 2667206 A	27-03-1992
			GB 2249001 A,B	22-04-1992
			GB 2258588 A,B	10-02-1993
			GB 2258589 A,B	10-02-1993
			IT 1258003 B	19-02-1996
			JP 2747985 B	06-05-1998
			JP 7294636 A	10-11-1995
			JP 2747986 B	06-05-1998
			JP 7294637 A	10-11-1995
			JP 2709758 B	04-02-1998
			JP 4232886 A	21-08-1992
			NL 9101344 A	02-03-1992
			NZ 239190 A	25-11-1994
			NZ 248087 A	25-11-1994
			NZ 248088 A	25-11-1994
			US 5481262 A	02-01-1996
			US 5422636 A	06-06-1995
			US 6054935 A	25-04-2000
US 4068232	A	10-01-1978	NONE	
EP 0440153	A	07-08-1991	DE 4002801 C	11-04-1991
			AT 142811 T	15-09-1996
			DE 69121923 D	17-10-1996
			DE 69121923 T	30-01-1997
			US 5073781 A	17-12-1991

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